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Impact of Different Factors on Premature Deaths in Rural and Urban Virginian Counties

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Population and Public Health

Scholarship in Medicine Proposal

☒ By checking this box, I indicate that my mentor has read and reviewed my draft proposal prior to submission (I am in the June/July short course with Dr. Todd)

Abstract

The goal of this investigation is to analyze data that influences premature death rates in Virginian counties. Specifically, I am looking at how the rates compare between rural and urban Virginian counties in 2020. In addition, I am analyzing how the premature death rates correlates with low birthweights, with air pollution, with preventable hospital stays, and with children in poverty and see how these variables predict the variance in premature death rates by county. I am using data from the County Health Rankings website. They gathered their data via surveys, the National Vital Statistics System, the CDC health tracking network, and the US census database. The 2020 estimates for these variables were based on data from previous years ranging from 2014 to 2018. I will be using paired and unpaired t-tests, Pearson/Spearman correlations, and stepwise linear regression to analyze my data.

Results: All Virginian counties were found to have a significant increase in their aggregate premature death rate from 2018 to 2020, increasing over a 1000 deaths per 100,000 hospitalizations ($t=4.496$, $p<.001$). The premature death rate for Virginian counties had significant positive correlations with low birthweights and preventable hospital stays.

Key Words: Virginia, poverty, low birth weight, rural, urban, air pollution, preventable hospital stays

Introduction/Literature Review

Over the years, the United States (US) has slowly shifted from being plagued by infectious disease to chronic disease.¹ These chronic diseases cause premature death where a person dies before the average age of death.¹ Premature death from chronic disease is usually preventable by limiting risk factors such as smoking, high body mass index, and high blood pressure.² A review noted that 10 out of the top 15 causes of premature death was chronic disease and that there has been a significant increase in the percentage of the population with chronic disease.² For example, obesity affected 30.5% of the US population in 1999 to 2000 and in 2009 to 2010, affected 35.7%.² Chronic disease can increase the rates of premature death but also increases the financial burden and cost in healthcare. For example, patients with 5 chronic conditions or more only make up 12% of the US population but comprise 41% of total healthcare expenditures. Their counterparts with no chronic conditions make up 40% of the US population but are only responsible for 10% of the nation's total healthcare expenditures.³ Premature death can be limited by addressing several different factors.

Premature death caused by chronic disease connected to preventable factors can increase the risk of avoidable premature death. A few factors that influence premature death are air pollution, rural residence, low birthweight, and living in poverty as a child. In a review article by Landrigan et al., a few studies found that air pollution can cause premature birth and can greatly impact the health and development of children. For example, in 2016, there were about 800,000 deaths in children 4 and under worldwide due to exposure air pollution.⁴ Air pollution can also increase mortality of patients with breathing problems. One study examining elderly populations in large US cities found that patients with chronic obstructive pulmonary disease (COPD) suffered an increase of 11% mortality to people without COPD in the same area ($p < .005$).⁵ On the other hand, mothers in Beijing, China were not found to have clinically significant changes in their children's birthweight even though they were exposed to air pollutants during pregnancy.⁶ Low birthweight in itself is a risk factor for premature death. In 2011-

2015, a study following 27 babies of very low birthweights reported that only 29.6% of these babies survived to childhood.⁷ Children with low birthweight that do survive tend to have developmental delays. Babies born with normal birthweights tend to have higher motor Bayley's scores than babies born with very low birthweights when evaluated at 9 months and 2 years ($p < .05$).⁸ Another influential factor on premature death is rural versus urban residence. Non-Hispanic white and non-Hispanic black residents in rural counties had significantly greater rates of premature death than their urban counterparts.⁹ A different study found that although rural white and black residents both had higher rates of premature death, there was still racial inequity with black residents having an estimated 362 years of life lost in comparison to rural white residents.¹⁰

Many studies have followed different variables and their impacts on premature death rates. Nevertheless, there is a lack of studies following the preventable hospital stays in the US and their impact on premature death rates. In addition, specific studies focusing on the relation of children in poverty to premature death rates in the US are not readily available. Although studies on air pollution, birthweight, and location of residence are available, a focused study of these factors by state may be missing. To measure the burden of chronic disease, the focus of this study will be on Virginian counties because Virginia has a large population with a good variation of classified rural and urban counties.¹¹

Research Questions

- **RQ1:** How does rate of premature death in Virginian counties in 2018 compare to 2020?
- **RQ2:** How does the rate of premature death differ between urban and rural counties in Virginia in 2020?
- **RQ3:** What are the correlations between the rate of premature deaths and rates of low birthweights, preventable hospital stays, children in poverty, and air pollution in Virginian counties in 2020?
- **RQ4:** What influence does children in poverty, low birthweights, air pollution, and preventable hospital stays have on the rate of premature deaths in Virginian rural counties and Virginia urban counties in 2020?

- **RQ5:** How does the rate of premature death differ between Virginian counties in 2020 and Ohio counties in 2020?

Methods

Context/Protocol & Data Collection

County Health Rankings calculated the premature death rate using years of potential life lost before 75 in Virginian counties for 2020 using the 2016 to 2018 data from the National Vital Statistics System (NVSS). The premature death rates for Virginian counties for 2018 were calculated using the data from 2013 to 2015. The data for air pollution is measured in micrograms per cubic meter (PM_{2.5}) and is an average daily density of fine-particle matter in the air. The data was obtained from the CDC National Environmental Public Health Tracking Network, and County Health Rankings calculated the pollution density for 2020 in Virginian using data from 2014. Low birthweight was measured by County Health Rankings as any birth that was less than 2,500 grams, and the estimate for 2020 low birth weights was calculated from data pulled from the NVSS for Virginian counties from 2012 to 2018. Children in poverty was measured by the County Health Rankings as all children living in poverty under the age of 18. Data on poverty from the 2018 US Census was used to calculate the children in poverty estimates for Virginian counties in 2020. Preventable hospital stays were measured by County Health Rankings as the rate of hospital stays for ambulatory-care sensitive conditions per 1,000 Medicare enrollees. The data was pulled from the Centers for Medicare & Medicaid Services Office of Minority Health's Mapping Medicare Disparities (MMD) Tool using the 2017 data to estimate the 2020 rates. Rural and Urban rankings were determined using data from the 2010 US Census, based on their 2010 urban criteria and data report. Counties were considered rural if greater than 50% of their population was considered to live in a rural area.¹¹ If counties had greater than 50% urban population, the county was classified as an urban county. If the county was split 50/50 on rural and urban population, it was placed under the rural category. There were 74 rural counties and 51 urban counties in Virginia.

For premature death rate data, 8 counties were excluded (due to being unavailable on the County Health Resources website) from the Virginia 2020 estimates, Highland county was excluded from the Virginia 2018 estimates, and all counties were used in the Ohio 2020 estimates. A county was excluded if there were less than 20 premature deaths in the 3-year time frame of measurement. Highland county and Manassas Park City were excluded from low birthweight data because the counties had less than 10 babies born with a low birthweight. All Virginian county data was used for air pollution measurements and children in poverty measurements. Bedford and Manassas Park City were excluded from the rate of preventable hospital stays because no patients were discharged under Medicare Part A during the 2017 measurement period for the 2020 estimate. A limitation to this data is that Medicare patients are usually 65 and older so trends in younger individuals' hospital stays may be missed by this data.

Data Analysis

To compare the premature death rate in all Virginian counties in 2018 to all Virginian counties in 2020 (RQ1), a paired t-test was used. To determine the difference between the premature death rate in rural Virginian counties compared to urban Virginian counties in 2020 (RQ2), an unpaired t-test will be performed with each county labeled rural or urban. Spearman correlations will be used to test the relationship of the rate of low birthweights, children in poverty, air pollution, and preventable hospital stays all to the rate of premature death in all Virginian counties in 2020 (RQ3). To visualize the impact of the rates of low birthweight, children in poverty, air pollution and preventable hospital stays on premature death rates in all rural Virginian counties in 2020 (RQ4), a stepwise linear regression will be used. A stepwise linear regression will be done with the same variables and all urban Virginian counties in 2020 as well (RQ4). To compare the rates or premature deaths in Virginian counties in 2020 to Ohioan counties in 2020 (RQ5), an unpaired t-test will be performed.

Results

When evaluating the premature death rates in Virginian counties in 2018 against 2020 (RQ1), a paired t-test found that the average premature death rate in Virginian counties significantly increased from 7894 deaths per year in 2018 to 8534 deaths per year in 2020 ($t=4.496$, $p<.001$) (Table 1).

Table 1: Premature Death Rates in Virginia

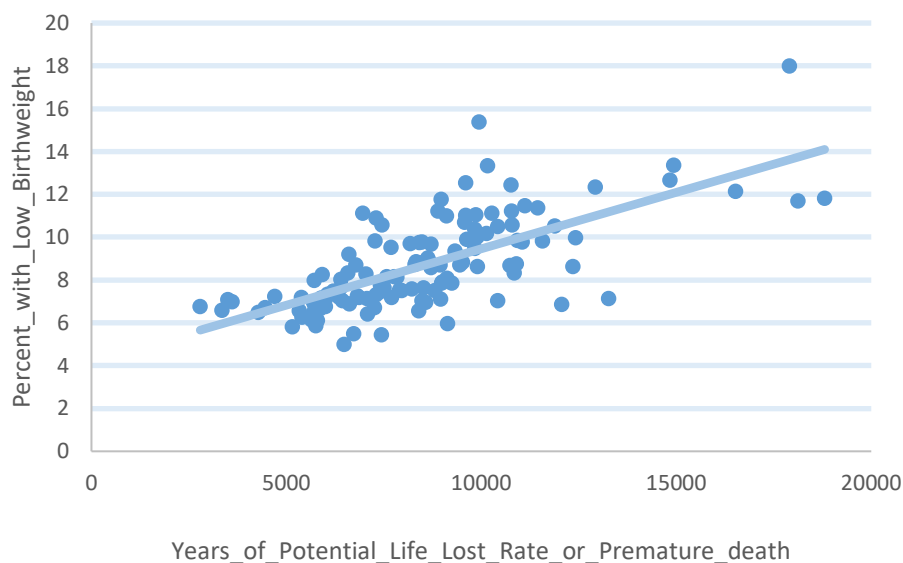
Year	N	Mean	SD
2018	125	7894.40 deaths/year	2475.18 deaths/year
2020	125	8533.78 ^a deaths/year	2840.59 deaths/year

Abbreviation: SD, Standard Deviation

^astatistically significantly different from 2018 ($p<.001$)

An unpaired t-test showed that the premature death rates between rural (8625 deaths/year) and urban (8400 deaths/year) Virginian counties (RQ2) were not significantly different ($t=.435$, $p=.664$). Another unpaired t-test comparing premature death rates between Virginian counties (8533 deaths/year) and Ohioan counties (8654 deaths/year) (RQ5) showed that the rates are not significantly different ($t=-.347$, $p=.729$). When examining how premature death rate correlates with the percent low birthweight in Virginia in 2020 (RQ4), a Spearman correlation showed a strong positive and significant correlation ($r=.710$, $p<.001$), whereas the rate of premature death increased so did the percent with low

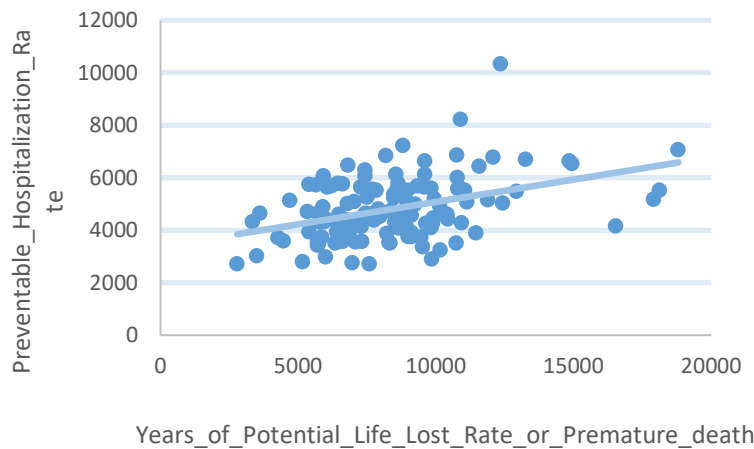
Figure 1: Correlation Between Premature Death and Percent Low Birthweights in Virginia 2020



A Spearman correlation indicates a large and positive significant correlation ($r=.710$, $p<.001$) where, as the percent with low birthweight increases, the premature death rate also increases.

birthweights (Figure 1). In addition, a Spearman correlation was done to investigate how premature death rate correlates with the amount of preventable hospital stays in Virginia in 2020 (RQ4). The Spearman correlation found a small, positive, and significant correlation ($r=.347$, $p<.001$), where the premature death rate rose as the number of preventable hospital stays climbed (Figure 2). A third Spearman correlation was done between the premature death rates and the percent of children in poverty in Virginia in 2020 (RQ4). The correlation discovered a strong, positive and significant correlation ($r=.802$, $p<.001$), showing that as premature death rate increases so does the percent of children in poverty (Figure 3). A Spearman correlation was done to compare premature death rate and air pollution levels in Virginia in 2020 (RQ4); however, no correlation was present, and the results were not significant ($r=.103$, $p=.254$).

Figure 2: Correlation Between Premature Death and Rates of Preventable Hospital stays in Virginia in 2020



A Spearman correlation shows a small, positive and significant correlation ($r=.347$, $p<.001$) indicating that the premature death rate increases as the preventable hospital stay rates increases.

Figure 3: Correlation Between Premature Death and Percent of Children in Poverty in Virginia in 2020

A Spearman correlation indicates a strong, positive and significant correlation ($r=.802$, $p<.001$) where, as the percentage of children in poverty rises, the premature death rate also rises.

The final research question (RQ4) studies how the percentage of low birthweights, percent of children in poverty, and preventable hospital stays by Virginian County in 2020 could estimate the years of potential life lost (premature death). A stepwise-linear regression indicated the best fitting model was significant ($F_{3,120}=77.85$, $p<.001$), encompassing about 66.1% of the variance in years of potential life lost. Percent of children in poverty contributed the most to the model ($B=162.46$, $t=6.436$, $p<.001$) with percent with low birthweight ($B=423.32$, $t=4.371$, $p<.001$) and the preventable hospitalization rates ($B=.338$, $t=2.487$, $p=.014$) significantly contributing as well. The air pollution levels in Virginia in 2020 did not significantly add to or impact the model.

Discussion

The premature death rate is climbing in Virginian counties based on the results of our unpaired t-test where the rate increased significantly from 2018 to 2020. We expected to the rate to vary minimally to show that the rate is stable is Virginia; however, it is increasing, supporting that chronic conditions may need to be addressed to reduce this rate. With a comparison to rural and urban counties in Virginia, the results showed that the premature death rate is not different between counties. This is unexpected because urban areas tend to have better healthcare, and two studies reported findings that rural counties

have a greater rate of premature death than their urban counterparts.^{9,10} For one such study, this data is especially surprising because the data was from County Health Rankings on 2017 premature death in Virginia.¹⁰ On the other hand, the fact that premature death rates were not significantly different between Ohio and Virginia shows that similar states are also suffering from high premature death rates. Important influential factors on premature death rate were highlighted by the significant, positive correlations of the premature death rate with low birthweights, preventable hospital stays, and children in poverty. A linear regression supported that these three variables were influential factors in increasing the premature death rate in Virginia with children in poverty being the strongest of the three. The results give a starting point for programs to address within Virginia to help reduce the rising rate of premature death in the state.

The connection of low birthweight to increased premature death rates is supported by two studies. One study stated that only 29.6% of children with very low birthweights survived to childhood.⁷ The other study reported that children of low birthweights had developmental delays based on the Bayley's score for development.⁸ Both these studies provide evidence for the connection of birthweight to premature death and addressing the causes of low birthweights may be worth addressing to improve the overall health of the population. Surprisingly, studies connecting children in poverty and preventable hospital stays to premature death rate seem to be lacking. The results of this study support addressing, at the minimum, childhood poverty to reduce the years of life lost in the general population. Another surprising factor is that the regression expressed that air pollution was not a significant influencing aspect to premature death rates in Virginia even though many studies have reported connections. For example, a study connected air pollution to 800,000 child deaths worldwide to levels of fine particle air pollution, and another study found that patients with COPD had an 11% increase mortality when exposed to high levels of air pollution.^{4,5}

From this study, Virginian populations both urban and rural are impacted by increasing rates of premature death. Virginian counties should focus on addressing the rising rate by combating the contributing influences such as childhood poverty, low birthweights and preventable hospital stays. These contributing factors could be reduced by focusing reducing chronic disease. A good example is preventable hospital stays. If smoking, high body mass index, and high blood pressure are better addressed, preventable hospital stays could decline, reducing the premature death rate.

Limitations and Future Directions

This study has a few limitations. First, the preventable hospital stay variable was calculated based on discharges recorded under Medicare part A, so younger individual's hospital stays may have been missed when the calculations were made. Another limitation is that air pollution measurements are an average concentration of air pollution and could miss short-term fluctuations or local patterns that may be impacting residents in Virginian counties. A future direction that should be pursued is that data should be collected on these variables at the individual level. All the data in this study was collected at the aggregate county level, and further study should investigate the impact on individual health. A study like this could help better direct the counties on how to reduce their premature death rates. In addition, another direction could pursue air pollution quality to better measure local patterns and shifts in county air quality because this study does not align with the literature on the negative impacts of air pollution.

Conclusion

This study identified differences or lack of differences between premature death rates and its influencing factors in rural and urban counties in Virginia. The results are important because they identify areas that need to be addressed on a state and county level to better address adverse health outcomes causing premature death in Virginian residents. Chronic disease may be connected to childhood poverty, low birthweights, and preventable hospital stays and should be areas of interest and focus for the Virginian counties. Actions that may improve these variables should be developed in state and county legislation

and should be areas of focus for social and medical programs in Virginia. By improving outcomes in these areas of focus, Virginia will not only decrease the years of potential life lost but also increase the quality of life for its residents by addressing some of their needs. As Virginia corrects these issues, it will serve as a valuable example to other states of similar rural and urban make-up such as Ohio.

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